

ComFiM: A Game for Multitouch Devices to Encourage Communication between People with Autism

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Abstract—At about 50% of the people diagnosed with autism have problems in developing any kind of functional language. Having this in mind, we developed a game, called ComFiM, for multitouch devices, aiming to encourage communication between people with autism. This paper presents the development and evaluation of ComFiM, exposing design decisions and results. ComFiM was developed based on requirements of a group of children with a severe degree of autism. The game was evaluated following research aspects related to the perception of each player's interlocutor and communication intentions observed between the players to collaborate with each other. Tests were carried out for 9 weeks with 4 children with autism. Results indicate that both the environment provided by the technology used as well as the design decisions of the game have stimulated the players' communication intentions.

Keywords—Autism, Communication, Game, Multitouch, Tablet, PECS.

I. INTRODUCTION

Autism is a developmental disorder which leads to impairments in skills related to three main areas: social interaction, communication, and repetitive and restricted behavior and interests [1] [2]. In the communication field, particularly, at about 50% of the people diagnosed with autism have problems in developing any kind of functional language [3]. Those who develop some kind of language usually have delays in their language milestones, such as in verbalizing their first words or in building communicative phrases. Others learn some words but show difficulties in using them to interact with others.

These facts show that the communication represents an important feature to diagnose autism. Moreover, this is an area that can affect the quality of life of these people. Taking this into account, this is a field to be explored in order to provide ways to encourage the development of the communication between people with autism.

Some studies aligning the use of technology with different approaches to encourage the communication between people with autism have been developed over the last few years [4] [5]. However, most of these studies aim to evolve the vocabulary of these people, but do not focus on the communication skills that can happen between them in an interactive process. Besides, many of these studies take into account general features of people with autism, but not the singular requirements

of the target people (such as the interest in technology, the difficulty facing the autistic triad, how much each one is affected by visual and sonorous stimulus). These aspects prove to be important to address, because the characteristics between individuals with autism can vary widely. Most of these studies also focus on the needs of people with a high functioning autism, which means a mild autism, with a lesser degree in language and social interaction impairments.

Knowing that the communication field plays an important role in the life quality of people with autism, we proposed and developed a game to encourage the communication between them. We choose to build a game due to the interest of these people, in general, in technology. This game is called ComFiM (acronym in Portuguese for Picture Exchange Communication for Multitouch Devices). ComFiM was developed taking into account specific features of the target group, which consisted in people with a severe degree of autism. Thinking about this target group, the game was developed for tablets, designed to provide a way that even nonverbal people with autism could play. The main contributions of this study are:

- Propose and develop a game to encourage communication as an interactive process, which can be customized to specific characteristics of the target group;
- Evaluate the contribution of ComFiM in the generation of communicative situations and the kind of intentions of communication generated by the target people to encourage their partner.

The document is organized as follows: in Section 2, we present some related work; in Section 3, we show the research methodology; in Section 4, we present the ComFiM itself, with its design decisions; in Section 5 there is the case study and, finally, in Section 6, we present the results achieved.

II. RELATED WORK

Among the studies found in the development of computer systems for people with autism, we highlight those that contribute to the development of communication skills.

In the communication field, many studies were performed in order to assist children with autism in vocabulary acquisition [3] [6] [7]. However, few works aiming to develop

the communication itself between children with autism were found. Moreover, we didn't find any study that considered the individual characteristics of the participants, but only general characteristics of autism.

Bauminger et al. [4] developed a project which aimed to allow children with high functionality autism to develop the communication via storytelling, using a multitouch table called "Story Table". The scenario is situated in the context of a visit to a museum and the children should, in certain points of the story creation, decide and agree on how the story would continue. According to the authors, after using the "Story Table", all children seemed motivated to create and tell stories. They also observed an increase in the number of positive social behaviors. In particular, they noticed a substantial increase in the amount of eye contact and emotions demonstrated, as well as interest in the partner.

Charlop-Christy et al. [8] conducted a study with children with autism in order to verify the efficiency of the use of the Picture Exchange Communication System (PECS) as a tool to assist speech, social-communicative behaviour and reducing behavioural problems. PECS is a system that allows people with impairments in communication to communicate through cards representing actions and objects. This system is explained in Section IV.

Closer to the present work is the project is developed by Hourcade et al [9]. In this project, four minigames for tablet were developed in order to enable children with autism to develop their social skills. The results indicate an interest of the children in the social aspect addressed by the games, as well as the fact that the use of technology can encourage the quality of social interactions between them. They also observed that non-verbal children demonstrate their thoughts and emotions through these games.

III. METHODOLOGY

The research methodology was divided in four cyclic steps (Figure 1). First, based on previous studies, we choose the technology to be used. We opted to use two tablets as the communication interface and a TV as a common place to the players, so that a player would not focus only on his/her own tablet. Actually, the fact that a common place provides a better interaction between the players and doesn't cause an indirection in the communication was a hypothesis to be evaluated. The tablet was chosen because aligning it with some strategies, like using audio to represent possible speeches from the user, we could provide a way that even non-verbal people with autism could play the game and work the communication field in an alternative way, having a device providing speeches for people that have difficulties to talk. Having this in mind, we start with the Requirement Analysis, taking into account basic needs of people with autism, which will be presented in the next Section. After this step, we build a prototype of ComFiM, based on the requirements gathered. The first prototypes were visual prototypes (prototypes that just include design aspects, but does not embody functions of the final game) including, e.g., the proposed game scenario, some speeches and the recorded audio of some speeches to be used by the tutor. An expert in autism evaluated these artefacts to verify, e.g., if the scenario were properly designed for the target group,

without many possible distractions, if the speeches were in an appropriate language and if the recorded audio had the proper intonation. The initial prototypes were evaluated just by experts, before using the game with people with autism. This prevents that, in the test sessions, the target group had a previous knowledge about how the game worked, which could interfere with test results. These prototypes were developed until we had a functional prototype (also called a working prototype), which would be the game itself, to be played by the target group.

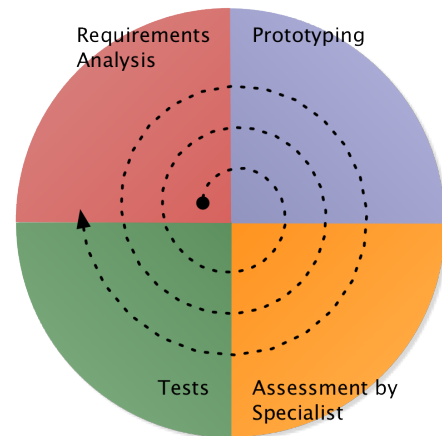


Fig. 1: Research Methodology

After this step, some tests were made. These tests included testing some approaches to verify whether they would benefit these people and the study case itself. As these steps were repeated during the game development, we represent they as an spiral process.

IV. COMFiM

To develop ComFiM, first we take some design decisions in order to provide a game that better fits the needs of the target group. They were:

- **Simple Interfaces:** The interfaces were projected to be simple, without much visual stimuli, so that we could maximize the chance of concentration, comprehension and learning of the players.
- **Guided Interfaces:** Difficulties may be reduced using a small set of answers in which one of them has to be chosen [10].
- **Visual Interfaces:** People with autism often have impairments in abstract thinking and in paying attention, and easiness in concrete thinking, memorization and in understanding visuospatial relationships [11]. They usually learn easily through visual representations [12].
- **Real Images:** We opted to use images as close to real objects/situations as possible, instead of infantile or cartoon style images. According to an expert in autism, this provides a greater chance of these people to recognize objects/situations.

- **Use of Tutor:** The game has a tutor which guide the user through it. This tutor explains how the game works, as well as the tasks that have to be performed by the players. Some previous tests were made to verify how people with autism interact with a tutor. To do this we used an educational game that has a tutor which guide the user. We verified that some children understood the given instructions, but did not execute them. Others presented echolalia, repeating some phrases spoken by the tutor. After a more detailed analysis, we found that the tutor has to “look” to the child. Beside, the instructions have to be short and presented in a simple language.
- **Communication based on the Picture Exchange Communication System (PECS):** This is a system based on image specifically developed for children with impairments in communication. Through it, children can communicate creating sentences by selecting pictures which represents objects and actions – a card “I want” and a card “Eat”. Figure 2 shows examples of PECS cards. This system has been used in different studies to encourage communication between people with autism [8] [13]. ComFiM adopted a communication based on PECS, so, to communicate with a partner, the child has to select an action and an object presented in the tablet.

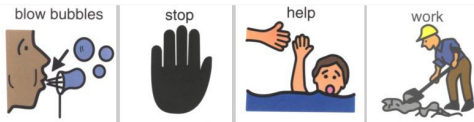


Fig. 2: PECS Cards

- **Customized Environment:** As each child with autism has particular characteristics and skills, ComFiM allows particular customization, according to the needs of each player. As much of these children with autism are also non-verbal and/or illiterate, the game makes extensive use of images and audio, adopting a communication based on PECS. However, all of these features can be customized. For a child which cannot read, for instance, text can be deactivated. Yet, for a child with this skill, it is possible to activate text, audio, or even a combination of the possible options. Table I presents all possible configurations.

TABLE I: ComFiM Possible Configurations

Game Configurations	
Text	Yes/No
Audio	Yes/No
Tutor	Yes/No
Animations	Yes/No
Level Detail	High/Moderate/Low
Level	Learning/Ask-Receive/Collaboration

ComFiM is composed by three levels, having a farm as a scenario. This scenario was chosen by the expert in order to

provide a scenario of interest for the majority of the children who would play ComFiM. The objects used in the farm scenario were chosen based on the vocabulary presented by the target group. In this farm, some tasks have to be done in individual (level 1) or collaborative (levels 2 and 3) ways, so that the player(s) achieve(s) success in the game.

In the game interface presented in the TV, as can be seen in Figure 3, in the upper right, there are four objects. To accomplish the tasks proposed by the tutor, the player has to use some of these objects. So, these options appear in the tablet interface (Figure 4) of the player of the current move. It is possible to choose between two actions showed in the tablet interface: “I give” and “I want”. We opt to work just with these two actions due to an expert statement, who identified them as essential actions to start to encourage the communication between people of our target group.



Fig. 3: ComFiM TV Interface



Fig. 4: ComFiM Tablet Interface

The game levels are:

- **Learning (level 1):** The player has to exchange messages with the tutor to perform some tasks, asking for an object or giving an object to achieve the goals. The tutor presents a situation to the player and various objects from which the player must choose the appropriate one. E.g., the tutor communicates to the player that some flowers have to be watered and presents four objects that could be used. The player sends a message to the tutor via the tablet, asking for, in this case, a watering can to complete the task.
- **Ask/Receive (level 2):** The players must perform tasks in the farm by exchanging messages via their tablets. Here, the tutor will play the role of a mediator to the communication, presenting situations that the players

have to solve jointly. The players have to share objects to achieve the game goals. The roles vary according to each move. E.g., assuming that Player 1 started the move, he/she should ask (“Give me”) Player 2 for an object to complete an specific task. So, Player 2 should give (“I give”) this object to Player 1 in order to complete the task. Then, at the second move, Player 2 should start the move and the roles will reverse.

- Collaboration (level 3): This level is similar to the previous one. But now, in a single move, each player has to play each possible role, helping each other to achieve a goal in common, working together. E.g., Player 1 should ask Player 2 for an object to complete part of the current task. So, as in the previous case, Player 2 should give it to Player 1. Then, to complete the task, Player 2, in the same move, should now ask for an object to Player 1, which should give it to Player 2. So, the basic difference is that in this level a deeper communication degree is needed.

Figure 5 presents the ComFiM structure of interaction. In level 1 (Figure 5a), the interaction occurs between one player and the tutor. On the other hand, in levels 2 and 3 (Figure 5b), the communication occurs between two players and the tutor is just a mediator of this communication. The yellow and blue arrows represents the communication between the players, through the tablet. The red arrow represents possible interactions that may occur between them, without the utilization of the tablet interface, which will also be considered in the results.

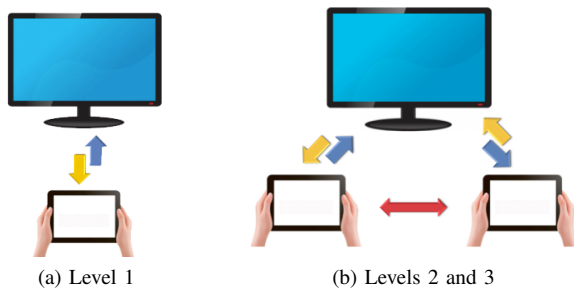


Fig. 5: ComFiM Interaction Structure

V. STUDY CASE

The study case counted with four children - *A*, *B*, *C*, *D* - with a severe degree of autism, which attend an specialized institute that collaborated with this present research. Table II shows some characteristics of the players. Then, we have a more detailed description.

TABLE II: Characteristics of the Players

Player	Age	Gender	Verbal	Literate
A	11	F	Y	N
B	11	M	N	N
C	5	M	N	N
D	5	M	Y	N

- Player *A*: She uses computer at least once a week, mainly for entertainment. *A* is also used to play on mobiles. *A* presents a good degree of communication intentions and a considerable vocabulary. Although, *A* has difficulties in pronouncing words and in keeping dialogue with others. Her communication intentions show mostly when *A* wants to play or has interest in something.
- Player *B*: He uses computer at least once a day, mainly for entertainment and to navigate the internet. *B* is also used to play on mobiles and video-games. *B* has difficulties and is unclear when answering or making questions and when talking about his feelings. He doesn't show many communication intentions, which are restricted for situations when *B* wants to participate in a game.
- Player *C*: He uses computer at least once a day, mainly to navigate the internet. He often presents interest in technology. Besides computer, he is used to play video-games. *C* has a mild impairment to communicate, talking seldom and by single words. He shows his communication intentions mainly by pointing to things and smiling.
- Player *D*: He uses computer at least once a day, mainly to play games and navigate the internet. He also plays on mobiles. *D* presents a moderate communication impairment, talking mostly when he sees something that he considers interesting.

The tests took place in a calm environment with minimum distractions for the players. The test sessions occurred during 9 weeks. Each session comprises various essays and it was limited by the concentration of the players. Each essay had a duration of 5 to 10 minutes. For each level, a session was finished when the players understand all different roles present to it. We totalized 9 sessions and 46 essays. Each session also had a therapist assisting the children, offering help and motivation for them, in case of need, mainly at level 1 (learning level). However, at each essay, the degree of help was reduced, so that the children could acquire independence on ComFiM. Due to an expert indication, pairs were formed between *A* and *B* and *C* and *D*, respectively.

The study procedure with the players comprised three steps, which were a pre-interview, the tests with the players itself and a post-interview. The pre and post interviews were both made with the therapist which assists the children. The first aimed to characterize the players, obtaining information about them, such as their degree of communication, whether they present communication intentions and their contact and interest in technology. These informations were briefly presented above. On the other hand, the post-interview aimed to collect the opinion of the therapists about the ComFiM and the children performance in the game.

VI. RESULTS AND DISCUSSION

The results presented in this section are separated by the game levels, since each level has its own goals and specific features to be explored. After this, a general discussion about the players performance is described. In all sessions, according to

an expert suggestion, we opted to use all multimedia resources present in ComFiM. At the first session, the tablet was given to the children only when they needed to communicate with each other in the game. Noting that all children have understood how the game works and how to control the tablet, this was lead for their own control during the other sessions.

A. Level 1

This level aims to familiarize the player with the game interaction and to identify how the player receives and perceives the messages sent by the tutor.

Player *A* had a good performance in this level, not showing any impairment with the game vocabulary. At the first session, *A* had full control of the tablet. However, *A* showed difficulty in sharing attention between the tablet and the TV, focusing on the first one. So, the therapist helped she to understand in which moments she had to pay attention to the TV and to the tablet. This situation exposes the difficulty of people with autism in sharing attention. After the therapist helps, *A* didn't have any other problems, understanding the game, the interface elements and the elements of communication that define when the player has to pay attention to the tablet or to the TV. So, *A* recognized that she had to answer some messages sent by the tutor and identified the need of asking for and giving objects showed in the game to accomplish the tasks.

Player *B* presents some impairments with the vocabulary, but along other sessions of this level, he showed to have acquired it. At first, *B* appeared not to be motivated with the game, which could be related to the existence of a little interest to the topic addressed in it. But in other sessions, he showed to be more interested, paying attention to the proposed activities and trying to do them. Furthermore, *B* had some confusion between the concepts "Give me" and "I give you", which should be used by the players to request objects or deliver them. *B* seemed to understand that when the tutor presented a task, he should reply via a message. However, *B* always answered with "Give me", not differing the situations. Thus, the aid of the therapist was essential. So, *B* needed some external stimuli to understand his role in the game.

Player *C* demonstrated a good degree of interest in the game. However, he had some difficulties in paying attention to the TV and handling the device, and impatience to interact via tablet (wishing a faster presentation of tasks). Such difficulties were related, by the therapist, to the young age of *C* and its restless characteristic. Despite these facts, *C* didn't show difficulties in understanding the tutor and his own roles in the game; his biggest problem was the difficulty of concentration.

Finally, player *D* proved to be very motivated with the game. In a few moments, after choosing the correct answer, he liked to click on the other options just to hear the sound which described each item. In other moments, *D* answered verbally to the tasks that the tutor presented. The therapist explained that he should respond using the tablet so that he could see an action in consequence of his answer. We can analyse this verbal response from the player as a positive factor, as it is generating some form of communication. Furthermore, *D* may have seen a communication partner in the tutor. As the player *C*, *D* also showed some degree of anxiety in the interaction. This suggests that the different characteristics of each range of

age need a deeper study. Perhaps, shorter tasks could be better for this age (5 years).

B. Level 2

The goals of this level are:

- Identify how each player understands the role of the tutor as a mediator and of his partner as a collaborator.
- Identify communication intentions showed by each player to motivate some action of his/her partner and thus achieve the goal of the game.

Initially, player *A* presented some difficulty to understand that she would no longer interact directly with the tutor, but with another player. However, after minor interventions of the therapist, *A* understood that now she should have to communicate with the other player in order to accomplish the tasks. *A* had a large number of initiative to help her partner (Figure 6). At first, *A* tried to carry out tasks for him, but along the sessions, *A* began to indicate the answer, sometimes even holding the hand of her partner and making the move with him. Furthermore, *A* repeatedly expressed herself verbally, when herself or his partner made a mistake, or chose the correct answer.



Fig. 6: Player *A* helping her partner

Player *B* demonstrated difficulty to understand that when his partner request an object in the game, he should deliver it. That is, *B* still showed difficulty to understand the difference between delivering and requesting an object, always answering with "Give me". Despite this fact, when the other player tried to make the move for him, *B* showed discomfort by pushing the hand of his partner (Figure 7) so that he could try to accomplish the move by himself. After some aid of his partner and the therapist, *B* seemed to understand the difference between the concepts "Give me" and "I give" as well as the fact that his role in the game varied depending on who initiated the move.

C, despite having interest in video-games, has a naturally restless behaviour, which harmed his concentration. So, for many times *C* needed help from the therapist, not because he didn't understand his roles in the level, but to properly pay attention and make the move. When *C* focused, he had no difficulties in performing the tasks. *C* is a non-verbal child and we did not observe communication intentions out of the

tablet between he and his partner, besides exchange of glances and interest on his partner activities (Figure 8). But, due the specific characteristics of *C*, these discrete intentions can be considered a significant result.

Finally, *D* remained motivated with the game and the technology. *D* quickly understood his role in the game, having to order and deliver objects to his partner, understanding that in this level the tutor was only a mediator between them. However, *D* had some problems due to the fact that his partner had difficulties to keep focused, which caused a break in the communication between them. So when the move returned to *D*, sometimes he had already forgotten what he should do. *D* had many verbal communication intentions, telling the answer to his partner when he did not answer.



Fig. 7: Player B showing discomfort with Player A trying to make moves for him



Fig. 8: Player C showing interest in his partner activities

C. Level 3

As mentioned previously, this level is similar to level 2, having the same goals. The difference is that, in this level, in the same move, both players must collaborate to accomplish a common task. So, in each move, both players play the two possible roles, i.e., they have to request and deliver objects at the same move and have therefore to differentiate the moments in which each of the roles has to be played. Here, the tutor remains present as a mediator between the players.

Both players, *A* and *B*, needed an initial help from the therapist to understand that they have different roles in the

same move, i.e., to perform a single task, they should play the role of delivering and requesting an object, in the correct moment, collaborating to achieve a common task. But both understood that the tutor continued as a mediator between them.

After the help of the therapist, *A* had no difficulty in playing the different roles, having a good performance at this level. We also noticed other communication intentions from *A*, such as, when her partner made some mistakes, hold his hand to help him to select the properly answer or tell him the answer verbally.

Player *B*, unlike what was observed in the other levels, showed some intentions of communication such as gestures and smiles when his partner made a mistake. *B* also showed interest in the activities of his partner, paying attention to his actions. Furthermore, *B* did not present more difficulties in differentiating the concepts of “Give me” and “I give”, knowing when to play each role.

Player *C* kept showing restless behaviour. Thus, *C* had difficulty to stay focused on the game. This may have occurred, besides the fact that *C* has this natural behaviour, due to the fact that *C* lost interest after repeated sessions, since at level 1 *C* showed good results. This, however, does not mean that *C* did not understand how the game and roles works. When *C* focused on the game, he performed the tasks quickly, without the need of help. Their main difficulty actually lies in focus.

The player *D*, as in the previous levels of the game, presented himself motivated. *D* had no difficulties in performing the proposed activities, this only occurred when the move began with his partner and, as he has difficulties to focus, it causes a break in the communication between them. When this occurred, when the move returned to *D*, he no longer remembered what he had to do.

As can be seen in Figure 9, ComFiM allowed the generation of fifteen different communicative situations between the players. We can see that the “Look to the partner” - a discrete communication intention - appeared more than the others. Nevertheless, we also can note that a large number of “direct” communication intentions was observed, such as verbally answers or verbal assistance to the partner.

Besides, due to an expert indication, we opted to present the game for the children with all available resources, including text, even though they were all illiterate. It is interesting to note that, even they could not read the texts, we noticed that they did pay attention to it. This may mean that they saw in this texts an indication that a communication was occurring, i.e., that the tutor was talking to them.

It is also important to note that the communication intentions raised in levels 2 and 3, comparing them to the level 1 (Figure 10). This is a good fact due to the worry that computers activities could, instead of providing a collaboration environment to people with autism, contribute to their isolation [7]. So, this figure shows that the children demonstrated more communication intentions playing with other people than with the tutor, which shows that this kind of technology, aligned with strategies to encourage jointly activities, may provide a way so that people with autism could improve their interaction, communication and collaboration skills.

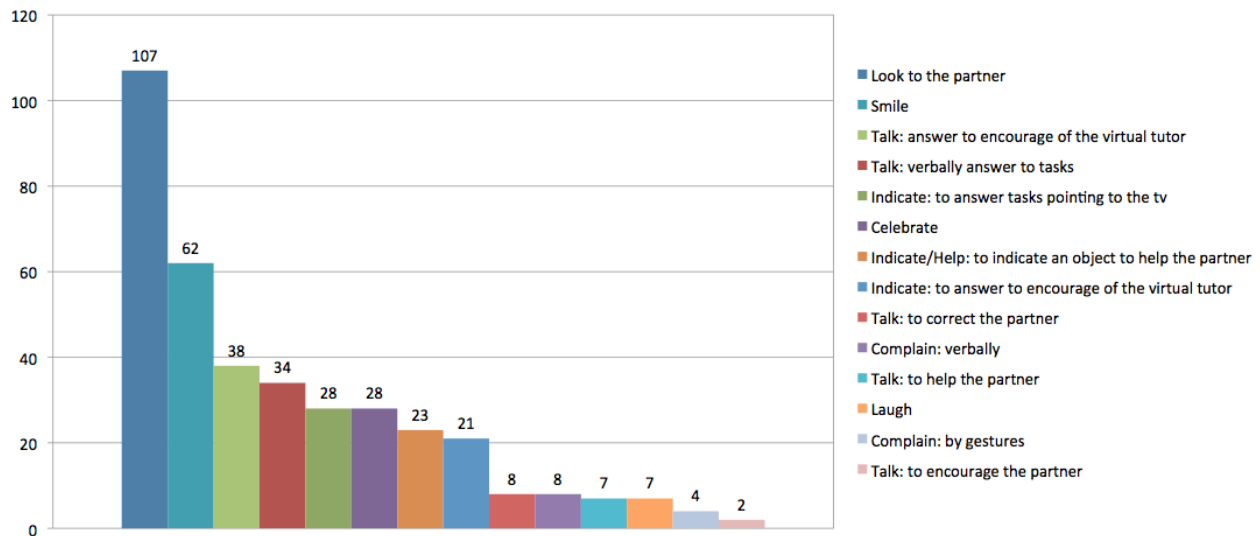


Fig. 9: Total Number of Communication Intentions

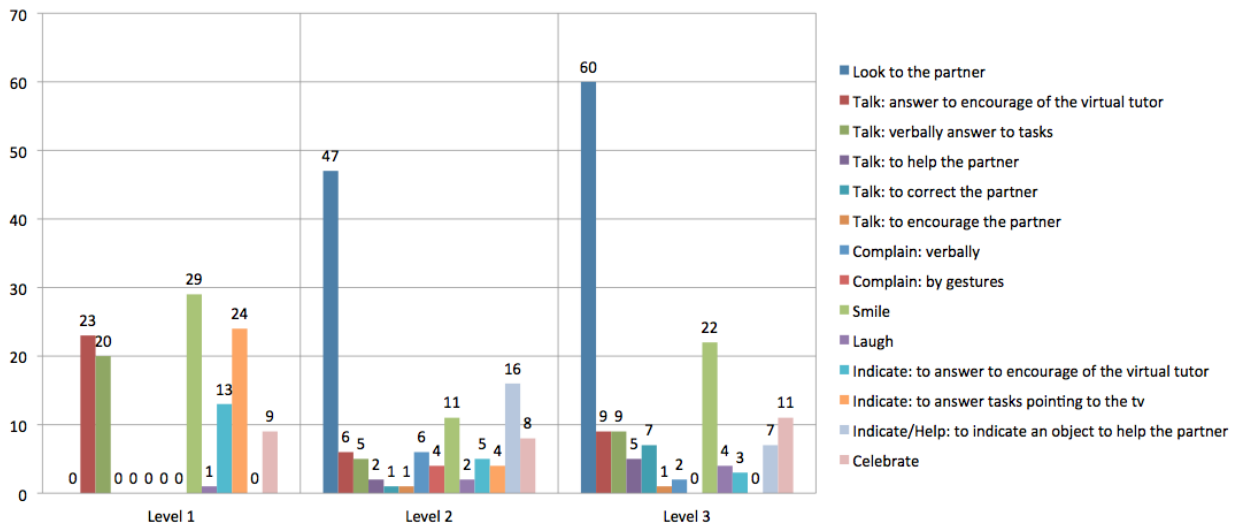


Fig. 10: Number of Communication Intentions by Level

VII. CONCLUSION

This work presented the development and evaluation of ComFiM, which aimed to verify if a collaborative game could be used to generate communicative situations among children with a severe degree of autism, as well as the communication intentions that could be presented for each child to motivate some action of his/her partner.

We observed that ComFiM allowed the generation of stimuli to communicative intentions, such as gestures, short phrases, signs and glances between the players. They also gradually understood the different roles in each level of the game, both of the tutor and of themselves. So, after a few sessions, they have differed when the tutor was a partner and when he was just a mediator in the game.

The structure of the developed game also shows that tablets can be used as a stimulator to collaborative situations among

people with autism, providing a tool through which even non-verbal players could interact with each other.

Despite the good results seen with children with eleven years old, it is noteworthy that, for younger children, such as the five years old children which participated in the research, the game should be modified in order to meet their difficulties related to the need of shorter and simpler phrases. It is also noted that, unlike many works found, the present study was developed in full partnership with experts, which allowed a greater understanding of the real needs of these target group as well as an increase in the chances that the game could be effectively used with children with autism.

VIII. ACKNOWLEDGMENTS

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